A Formula for the Rotation Periods of the Planets & Asteroids

Subhash Kak
Department of Electrical & Computer Engineering
Louisiana State University
Baton Rouge, LA 70803-5901, USA
FAX: 225.388.5200; Email: kak@ee.lsu.edu

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Abstract

The note presents a formula for the prediction of the rotation periods of the planets and asteroids. This formula, which is like the Titius-Bode law, gives a good agreement with the rotation periods of most planets, shows that Venus is retrograde, and that there must be five objects between Mars and Jupiter. This formula may be of some relevance in understanding the dynamics of the early solar system.

Keywords: Rotation periods, solar system, Titius-Bode law.

It is generally believed that the Titius-Bode relationship between the distance of the planets from the sun may have some significance regarding the formation of the solar system. If there is a similar simple pattern defining the rotation periods of the planets then that may also provide clues regarding the dynamics of the early solar system. In this note I present a simple relationship that is in good agreement with the rotation period information of the superior planets, and it indicates that Venus has retrograde rotation although it does not give an accurate value of the rotation of this planet or Mercury.

Instead of considering the rotation periods directly, I consider $M = \frac{d}{p}$, where d is the distance from the sun in astronomical units (AU) and p is

the rotation period in days. M is a measure of the relative speed of the sun across the horizon. The sequence for increasing M is not exactly the same as the sequence in terms of distances from the sun. For example, the positions of Venus and Mercury are reversed and we will see later that our formula indicates 5 objects between Mars and Jupiter—these could be asteroids and Pluto—and one between Jupiter and Saturn (another asteroid).

The table below gives M, and its offset value $Q = M + 0.337$, for the planets in order of increasing values are:

planet	$M = \frac{d}{p}$	Q = M + 0.337
Venus	-2.98×10^{-3}	0.334
Mercury	6.6×10^{-3}	0.343
Earth	1.00	1.337
Mars	1.487	1.824
Pluto	6.17	6.507
Jupiter	12.5	12.837
Saturn	21.53	21.867
Uranus	29.51	29.847
Neptune	39.04	39.377

The $Q = \frac{d}{p} + 0.337$ values of the major asteroids are:

> Ceres (7.16), Pallas (8.86), Juno (9.17), Vesta (11.02), Astraea (4.0), Hebe (8.326), Iris (8.38), Hygiea (4.42), Eunomia (10.76), Euphrosyne (14.08).

These numbers and those in the Table above have been computed from the information in Reference 1.

We now propose the following formula for the Q-numbers for the planets:

$$Q(n+1) = 1.361Q(n) \tag{1}$$

where $Q(0) = 0.2863$. This means that the period, $p(n)$ in days, of the nth planet is given by:

$$p(n) = \frac{d(n)}{(1.361)^n \times 0.2863 - 0.337} \tag{2}$$

Here the sequence order is Venus (0), Mercury (1), Earth (5), Mars (6), Jupiter (12), Saturn (14), Uranus (15), and Neptune (16).

Given 17 items, one can interpolate by using a polynomial that is of 16th degree, with 17 constants. Our formula uses just 3 constants and the Q-values are fixed by only 2 numbers. So our formula provides significant compression of information. An interesting question to ask is: What is the best that can be done in terms of such compression?

Beginning with the $Q-$number for earth in this sequence, namely 1.337, and multiplying successively by 1.361, We get the numbers:

$$1.337, 1.820, 2.477, 3.371, 4.587, 6.243, 8.497, 11.565, 15.740, 21.422, 29.155, 39.680$$

We obtain good agreement with the value for Mars (1.820), which is followed by 5 additional values (these could be asteroids and Pluto), the value for Jupiter (11.565) which is off by about 10 percent, another value (15.74) that is near the correct value for the asteroid Euphrosyne (14.08), and then very good agreement with the correct values for Saturn, Uranus, and Neptune.

Considering the values intermediate to those for Mars and Saturn, we have: 2.477 (no asteroid known to the author); 3.371 (Astraea); 4.587 (Hygiea); 6.243 (Ceres; but Pluto is closer); 8.497 (Hebe, Iris, Pallas); 11.565 (Vesta, and Jupiter); 15.74 (Euphrosyne).

On the other hand, by dividing 1.337 successively by 1.361, we get:

$$0.982, 0.722, 0.530, 0.390, 0.286$$

There are no objects for the first three of these values; the next two, come closest to the values for Mercury and Venus. When the constant 0.337 is subtracted, the M values for Mercury and Venus obtained from the formula are 5.4×10^{-2} and -5.0×10^{-2}. These are about one order of magnitude off, but provide the correct direction of rotation for Venus.

When we consider the above information in conjunction with the Titius-Bode law, it becomes clear why there could not be a single planet at the distance of 2.8 AU, because our rotation formula calls for 5 objects between Mars and Jupiter.

The extra three inferior planets provided by the formula with the values of $Q = 0.532, 0.723, 0.983$ may have been captured by the earth and Mars as their satellites: Moon, Phobos, Deimos.

Our formula (1) depends on just 2 constants: the multiplication factor of 1.361 and the starting value for $Q(0) = 0.2863$. That just two constants

are able to provide a good fit for the rotation periods of most of the planets and many asteroids suggests that this formula may be of some relevance in representing the dynamics of the early solar system.

Reference

1. V. Illingworth (ed.), *Dictionary of Astronomy.* (Facts on File, New York, 1994)